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Rapid Fat Production by Ground Squirrels Preceding **Hibernation**

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Mammals that normally live through extended periods of inactivity, in a state of torpidity, follow the general pattern of increasing the amounts of fat in their body tissues for such emergencies. Those species that behave in the remarkable manner of becoming cold-blooded while in this state with the metabolic processes greatly reduced, the blood circulation, respiration and heat production being at a low level, are physiologically adjusted for the production of the necessary reserve fat for hibernation within a definite and, in some cases at least, a limited time.

Ground squirrels, among those interesting mammals that become cold-blooded in the torpid state, provide one of the best examples of a hibernator that can convert its food into large amounts of fat in the short time it has at its disposal. In the spring, upon emergence from hibernation, these squirrels are very lean, often emaciated, and it takes some weeks for them to recover and to return to normal weight. In the meantime the rutting season has intervened to retard this process, and with the females there is the added drain of nursing the young. By the time fat-producing foods, such as seeds, grain, etc., are abundant and squirrels can give most of their waking hours to foraging, the active season is well advanced with but a few weeks remaining in which to store up the fat reserve needed for the season of hibernation, which usually starts early in September in Nebraska. That they can do this has been amply demonstrated here with the forms native to this region, particularly the species *Citellus tridecemlineatus* which we have used in considerable numbers in general behavior studies.

These findings correct a general assumption that such mammals need most of the summer in which to store up enough fat to carry them through

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the long months of inanition. In fact, adult ground squirrels can accumulate the amount of fat usually used up during hibernation within two or three weeks in the summer season, when food is abundant and the appetite is keen.

Under controlled conditions a number of squirrels have increased their weight nearly one-fourth in one week when given abundant food. An increase of 30 or more grams in one week is not unusual when in thin or medium flesh. That this occurs also in the wild state is evidenced by frequent trapping of individuals and comparison of the stored fat, both internal and subcutaneous, with that of captive squirrels during this season.

TABLE 1

Squirrel	Time in weeks	First weight in grams	Second weight in grams	Weight gain in grams
1	1	228	260	32
2	1	167	215	48
3	1	185	211	26
4	1	186	225	37
5	1	166	194	28
6	1	179	207	28
7	1	172	202	30
8	1	182	215	33
9	2	153	217	64
10	3	186	284	98

Table 1 gives the weight increase in one week of eight squirrels, the increase in two weeks of one squirrel and the increase in three weeks of one squirrel. The last two examples, of two and three weeks, are added to show that this rate of increase can be maintained for the limited time before onset of the hibernating urge and will be sufficient for the long fast should a fourth or even a third of the body substance be used up as frequently occurs. These are representative selections from a series of the 13-lined species. That the two other native species can do equally well is supported by two cases taken from a number of records obtained: a *C. franklinii* made a weight increase of 66 grams in one week, from 648 to 714 grams, and a *C. spilosoma obsoletus* gained 34 grams, from 86 to 120 grams, in one week.

This power of building up fat reserves so rapidly indicates a physiological adjustment of a high order of efficiency in the digestion and assimilation of food in ground squirrels. Evidently an inherent quality, it appears to be a part of the evolutionary development of these hibernators that normally exhibit periods of cold-blooded existence; it is not excelled by any other mammalian races known and is probably equalled by few. To compare the human species with them, a man weighing 167 pounds to do as well as squirrel No. 2 would weigh 215 pounds at the end of one week, a gain of 48 pounds. Or, compared with No. 10, a man weighing 186 pounds, in three weeks would go to 284 pounds for a gain of 98 pounds (Table 1).

The conclusion seems reasonable that this rapid fat-conversion ability, coupled with another, sets these forms apart in effecting these remarkable adaptive adjustments as survival devices. The other adjustment is the striking phenomenon whereby these species, typically homoiothermal, can pass readily into a cold-blooded state as they sink into a deep torpor and then, without apparent ill effects, just as readily regain the warm-blooded condition and normal activity.

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